



**Direct Traffic Control**

**SAFETY CASE**

**Risk Assessment Evidences**

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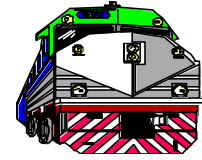
## ASCAP Work-In-Progress

- **CSX: DTC/CBTM**
- ***New York City Transit:* Communication-based Train Control (CBTC)**
- ***Maglev, Inc:* Transrapid Maglev System**
- ***Lockheed Martin/IDOT:* Positive Train Control (PTC)**

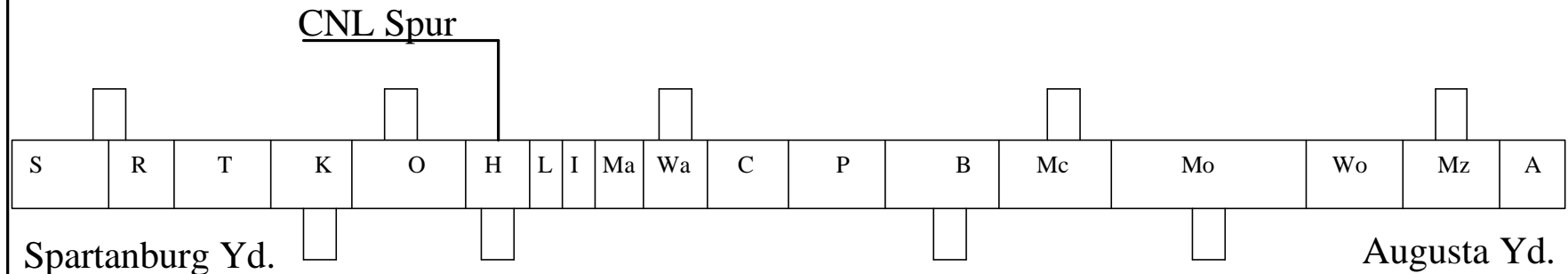


## CSX DTC Safety Case Evidences Slice

- Human-factors
- Human-factors
- Switch Group
- Bridge Group
- Broken Rail Group
- All Object Groups
- Total System Risk



## DTC Train Line



### OBJECTS ALONG TRACK:

- 251 Curves
- 135 Crossings
- 128 Milepost markers
- 63 Switch Points
- 18 Bridges
- 36 Speed Zone Signs
- 36 Block Boundaries
- Maximum of 30 Trains

S : Spartanburg Block  
R : Roebuck Block  
T : Tyger Block  
K : Kilgore Block  
O : Ora Block  
H : Hunter Block  
L : Laurens Block  
I : Irby Block  
Ma : Maddens Block  
Wa : Waterloo Block  
C : Coronaca Block

P : Park Junction Block  
B : Bradley Block  
Mc : McCormick Block  
Mo : Modoc Block  
Wo : Woodlawn Block  
Mz : Martinez Block  
A : Augusta Block



## DTC Assessment

### CBTM Automatic-centric

Dispatcher

### DTC Human-centric

Digital Communications

Voice Communications

On-Board Enforcement  
Automation

Train Crew Locomotive  
Operation

Enforcement:

- Speed
- Location

Operation:

- Speed
- Location

Coverage: Automatic-centric

Operation: Human-centric



## Risk Assessment

**Risk<sub>CBTM</sub> <<<< Risk<sub>DTC</sub>**

**Subject to: A High Degree of Confidence**

**And: MTTHE Compliance for all Objects**

**Subject to: A High Degree of Confidence**



## RISK CURVE



$$Risk_{CBTC} \ll Risk_{Canarsie}$$



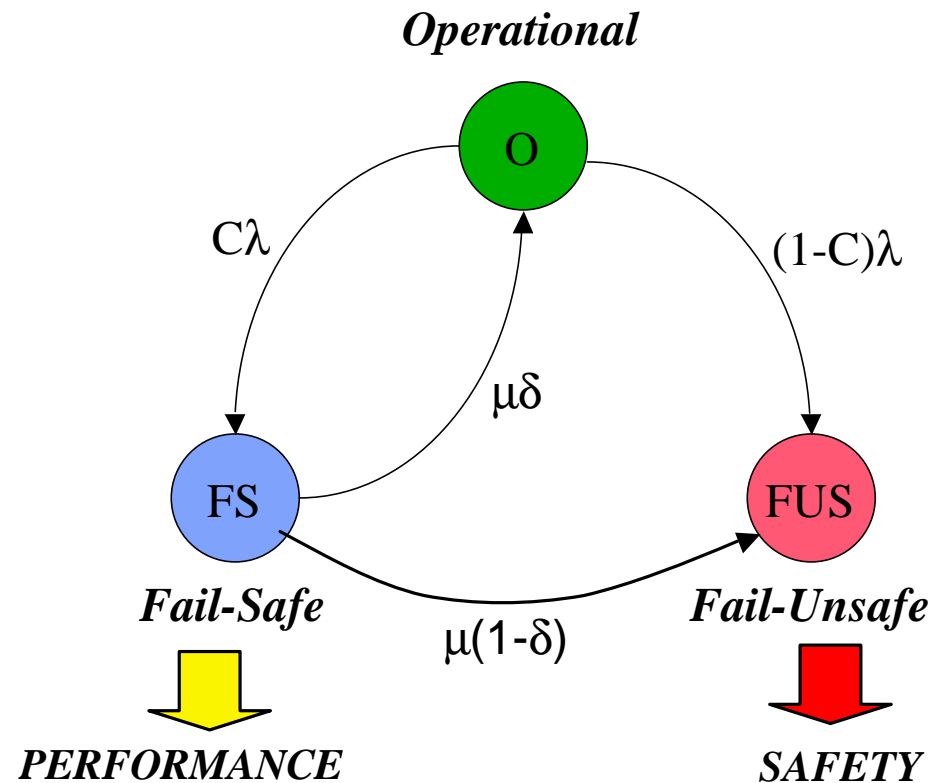
## Physical Object Modeling

**$\lambda$**  : Failure Rate

**$C$** : Failure Coverage

**$\mu$** : Repair Rate

**$d$** : Repair Coverage



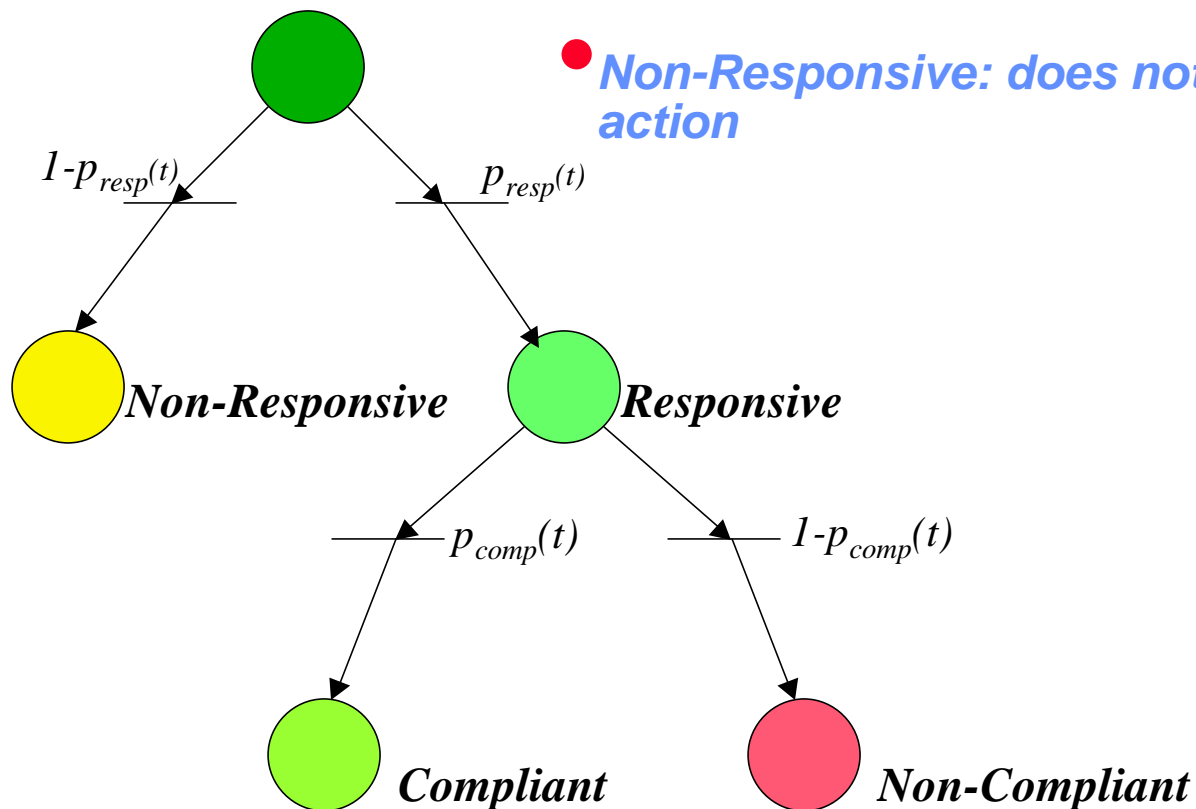




## Human-factors Model Framework

- *Responsive: recognizes need for action*
  - **Compliant: performs correct action**
  - **Non-Compliant: performs incorrect action**

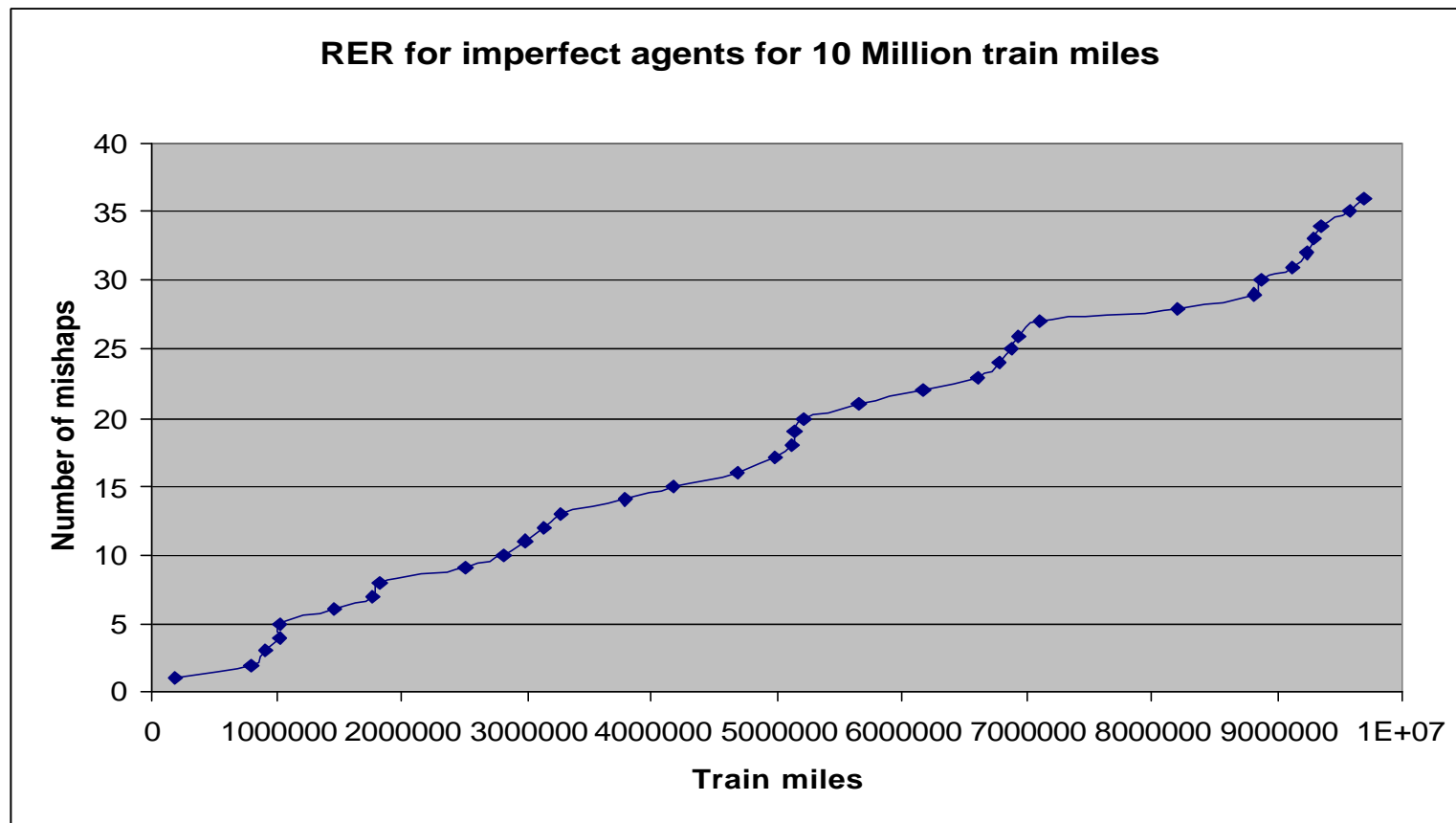
- *Non-Responsive: does not recognize need for action*





## RISK: Human-factors Non-Compliance

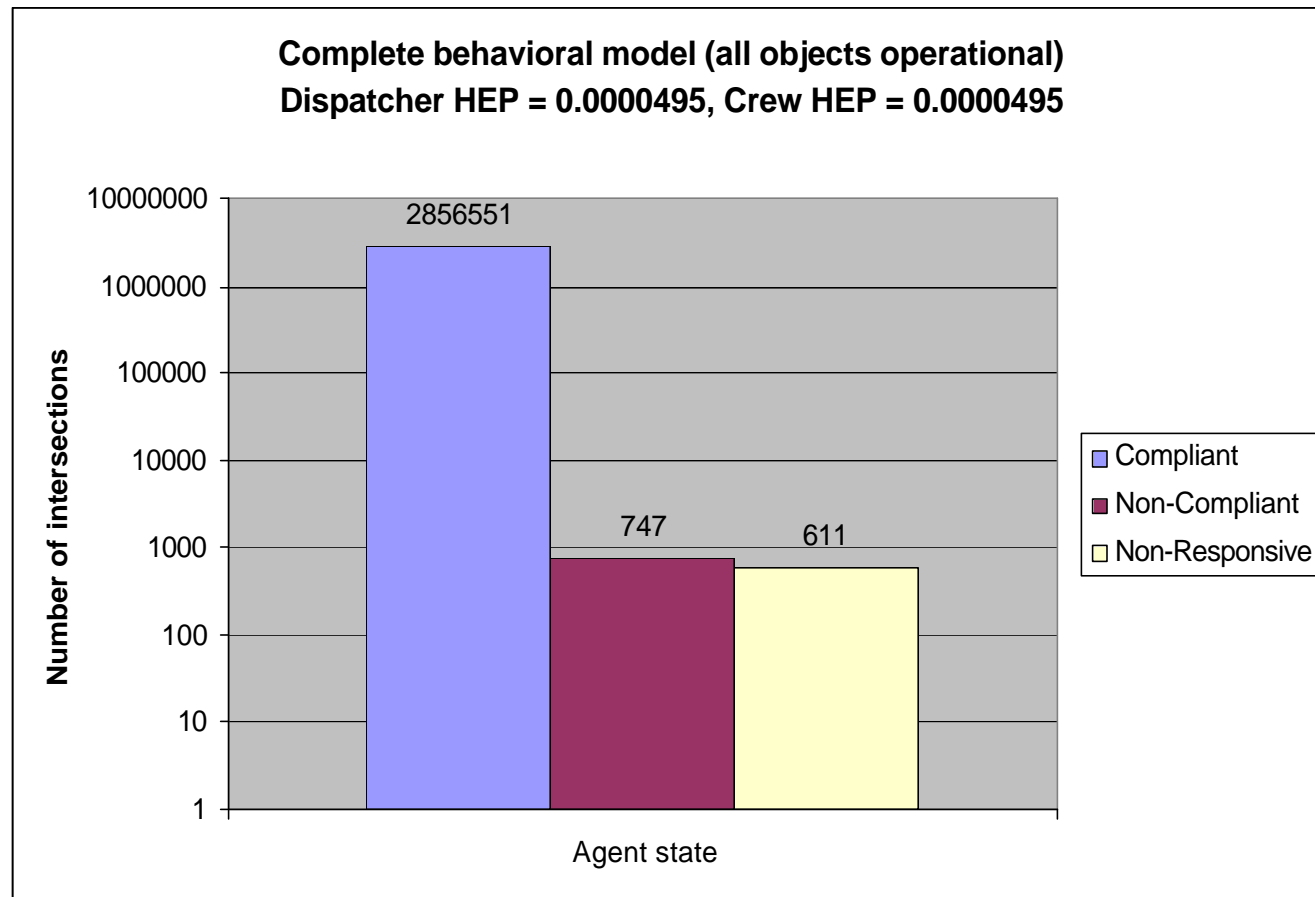
### CASE 1: All Objects Hazard-free

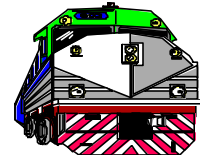




## Histogram: Human-factors Non-Compliance

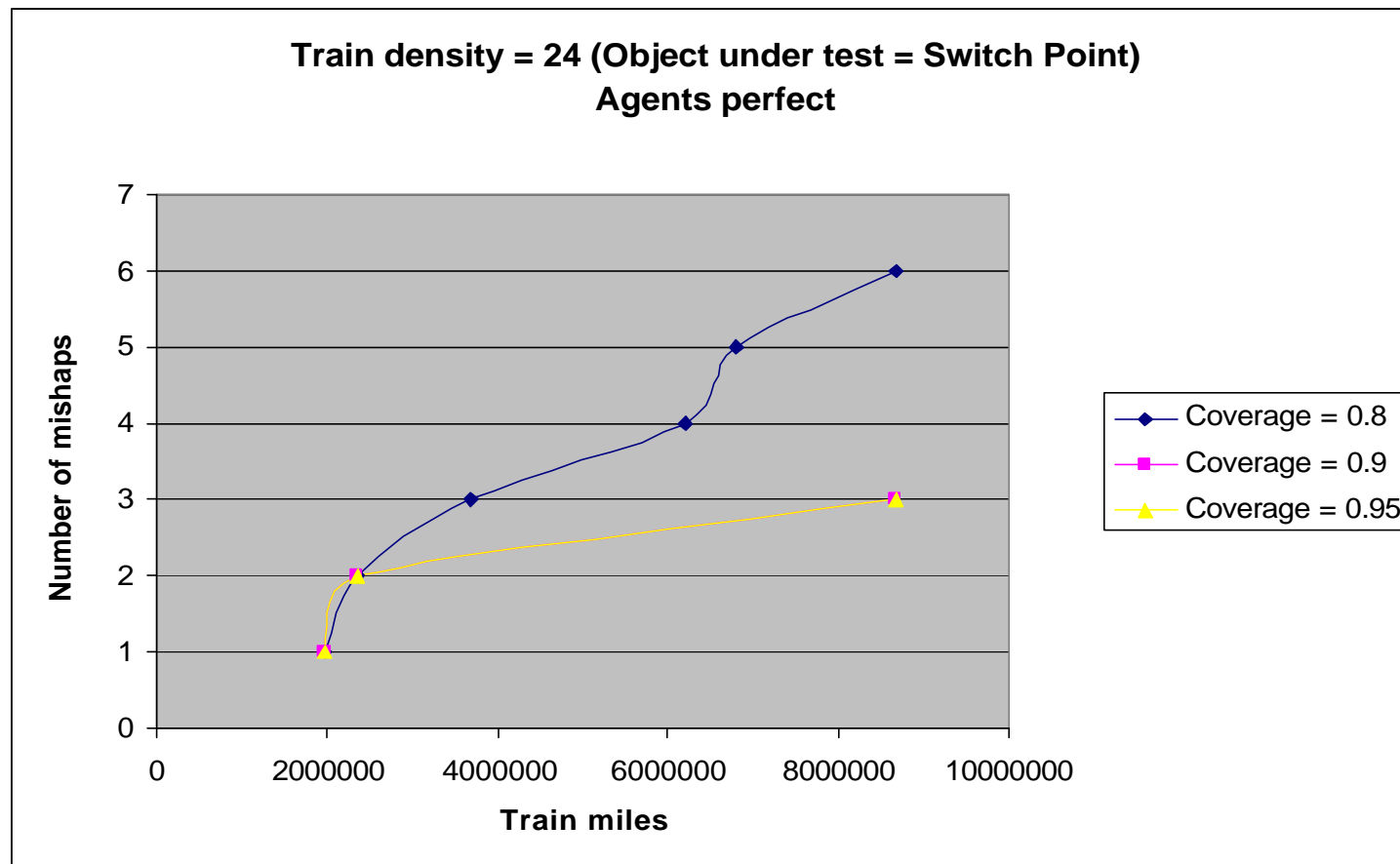
### CASE 1: All Objects Hazard-free





## RISK: Human-factors Compliance

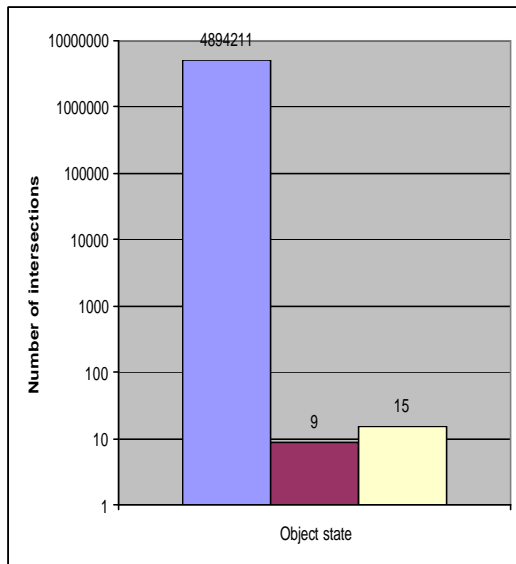
### CASE 2: Switch Group Non-Hazard-free



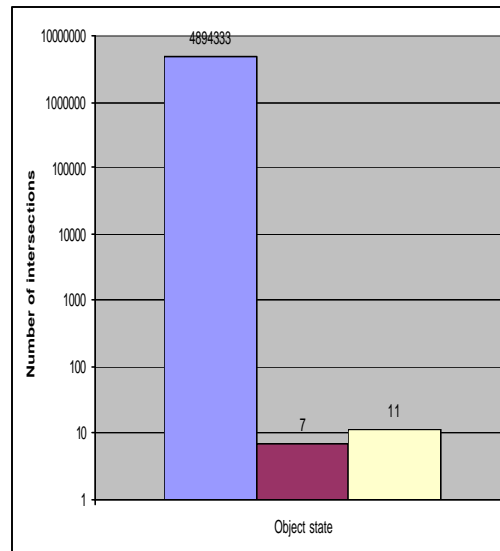


## Histogram: Human-factors Compliance

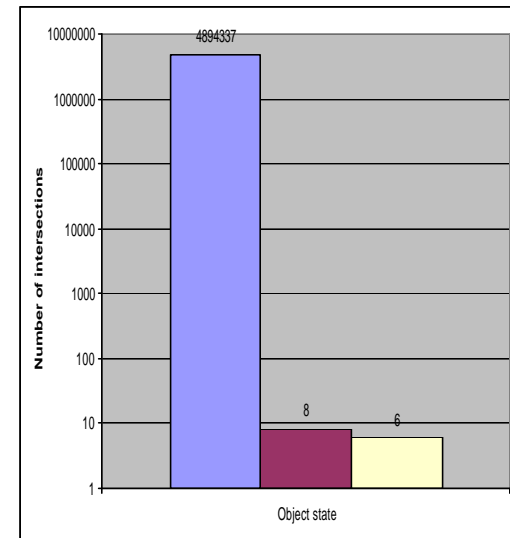
### CASE 2: Switch Group Non-Harzard-free



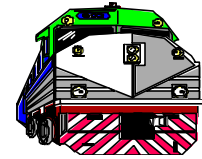
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Coverage = 0.9

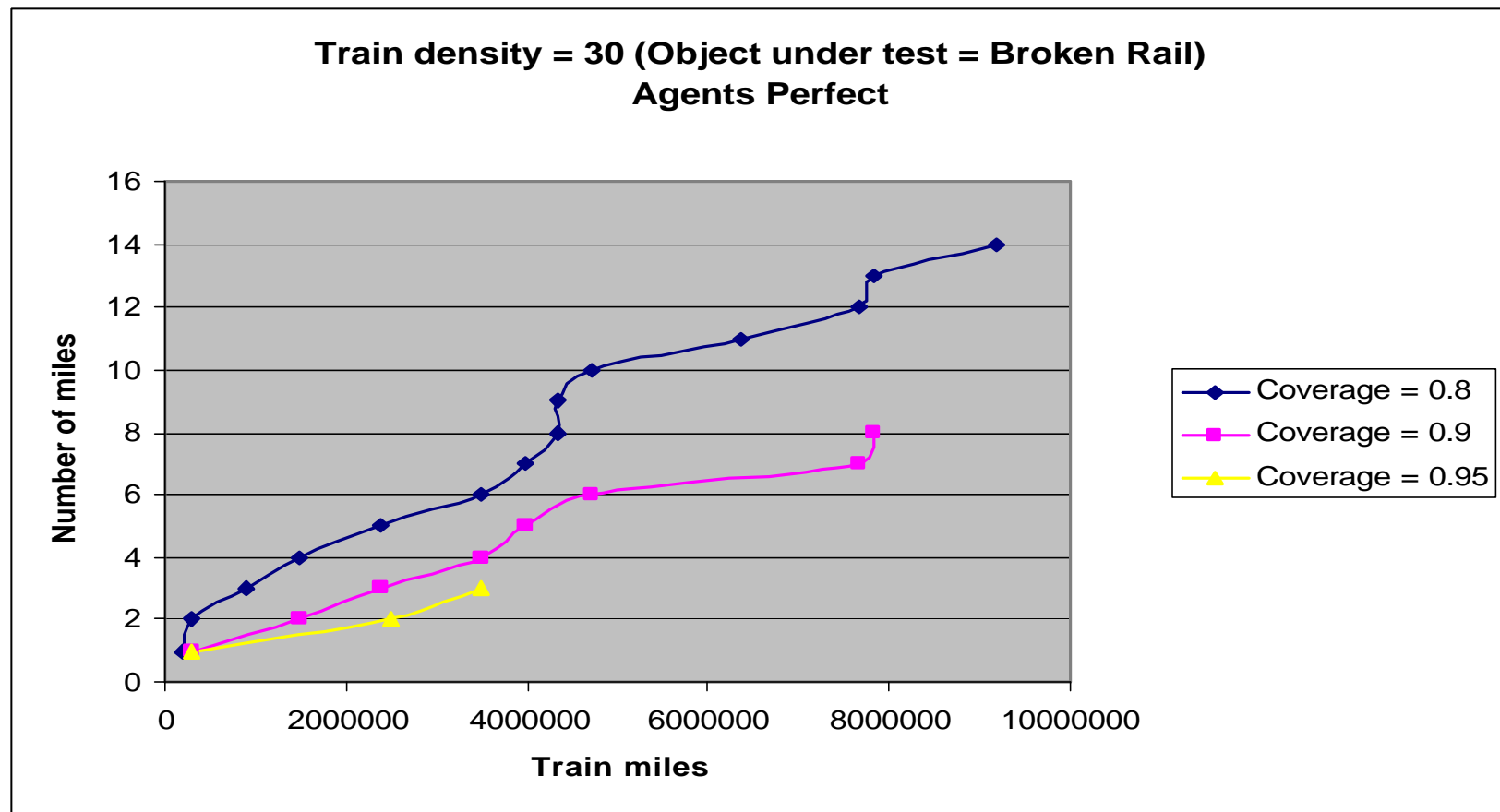


Coverage = 0.95



## RISK: Human-factors Compliance

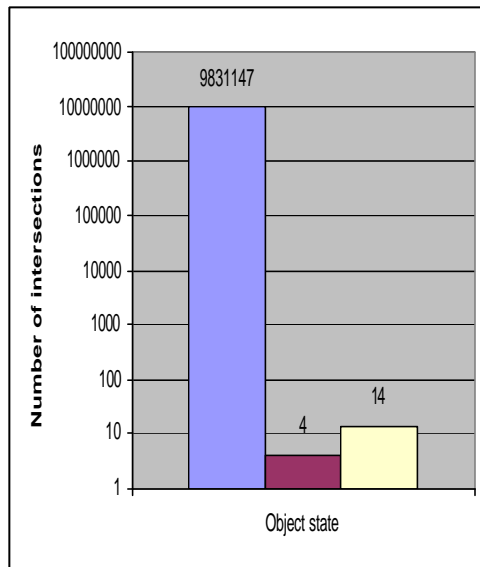
### CASE 3: Broken Rail Group Non-Harazard-free



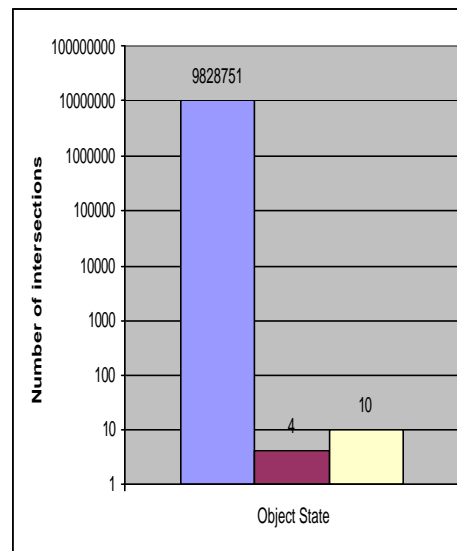


## Histogram: Human-factors Compliance

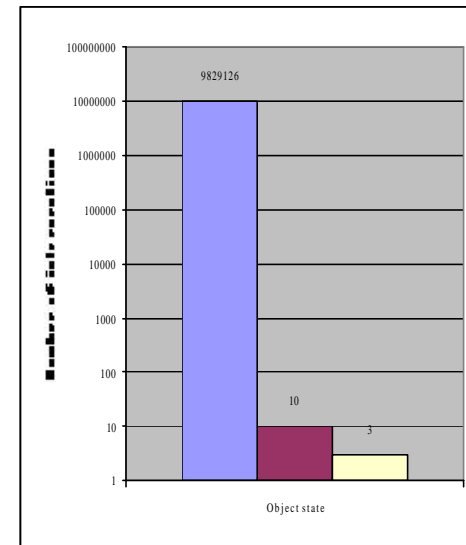
### CASE 3: Broken Rail Group Non-Harzard-free



Coverage = 0.8



Coverage = 0.9

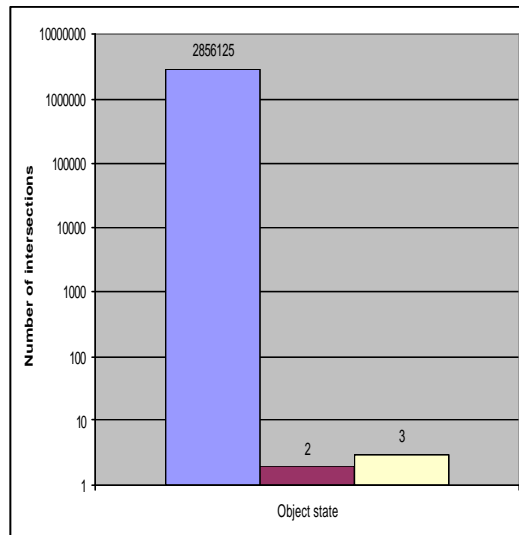


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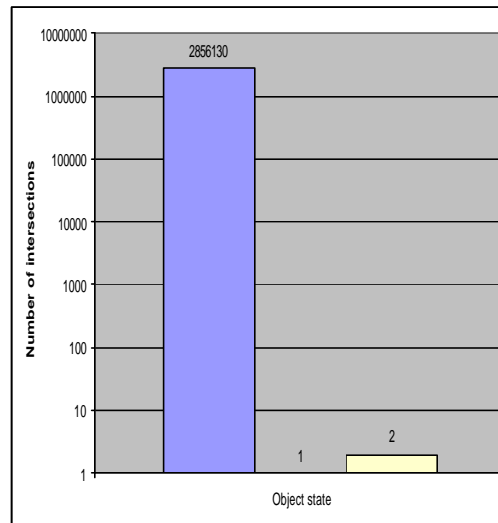


## Histogram: Human-factors Compliance

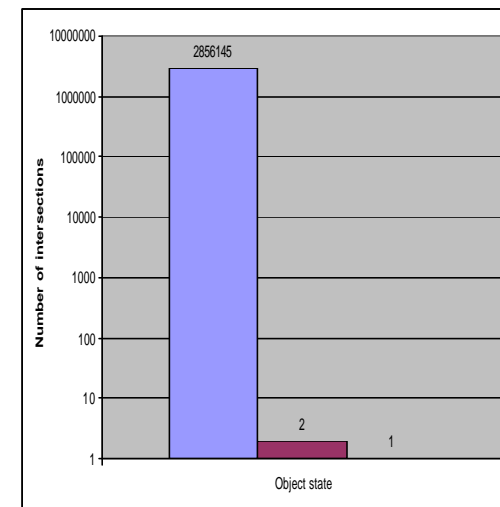
### CASE 4: Bridge Group Non-Harazard-free



Coverage = 0.8

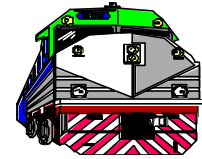


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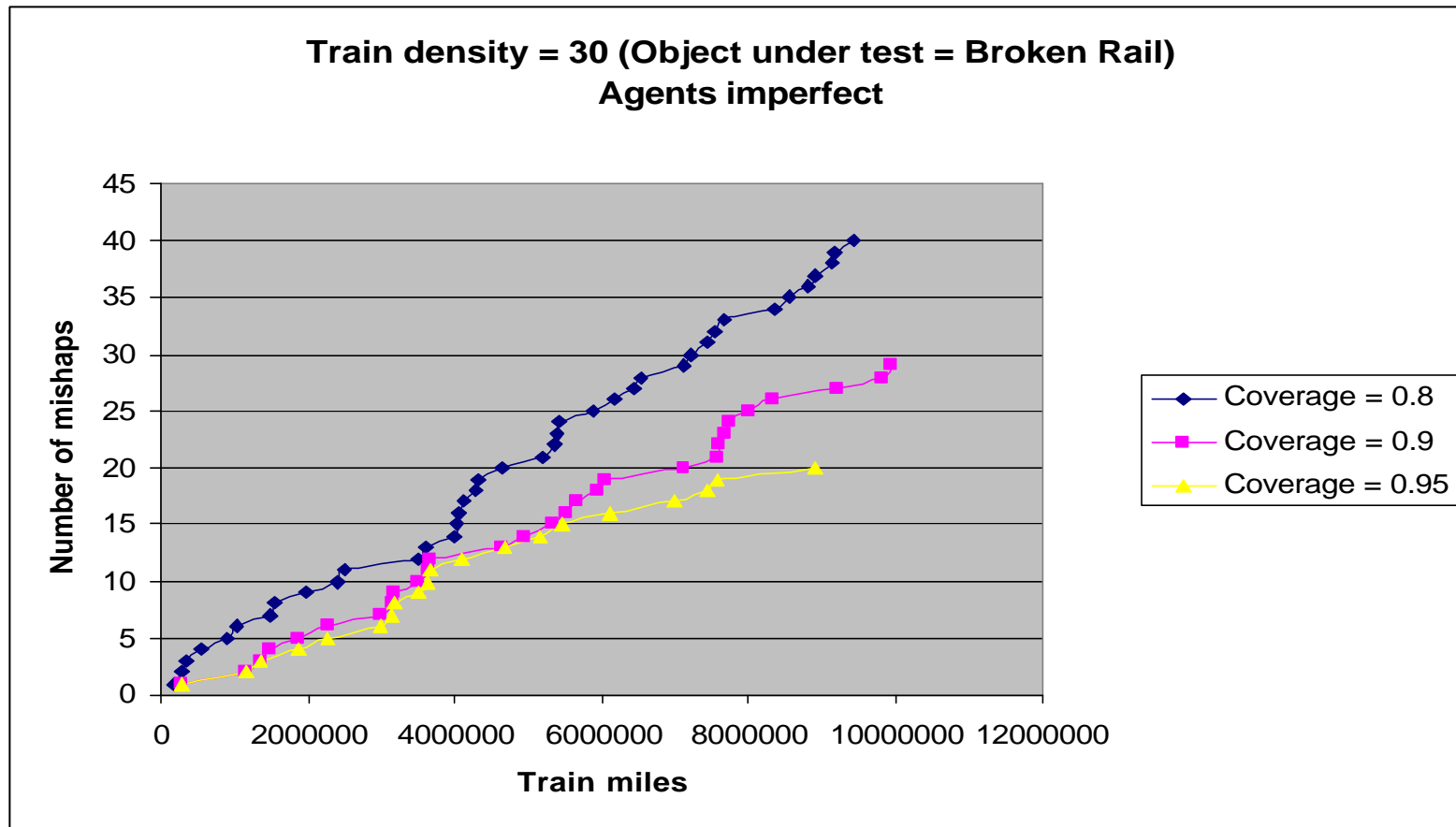
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## RISK: Human-factors Non-Compliance

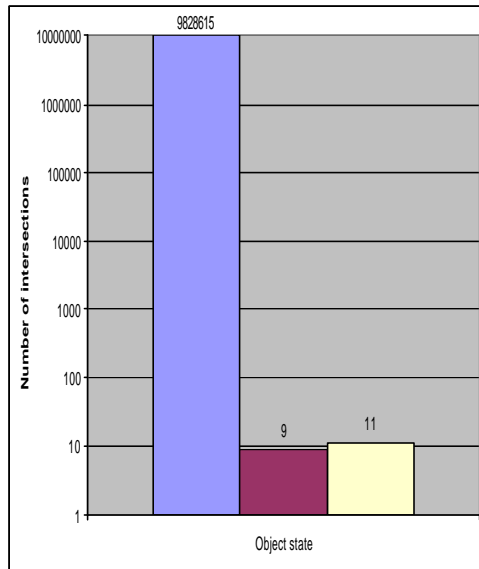
### CASE 6: Broken Rail Group Non-Harazard-free



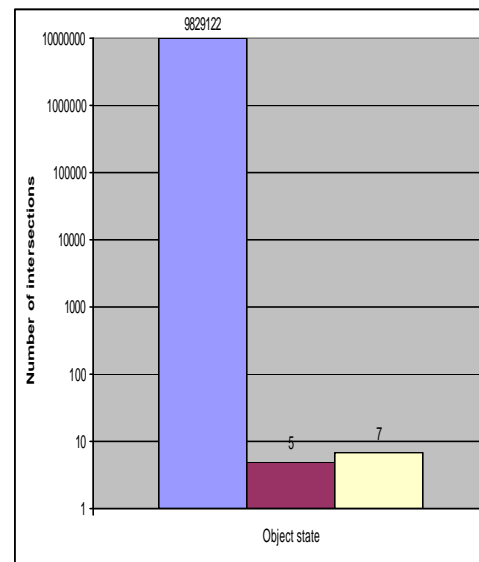


## Histogram: Human-factors Non-Compliance

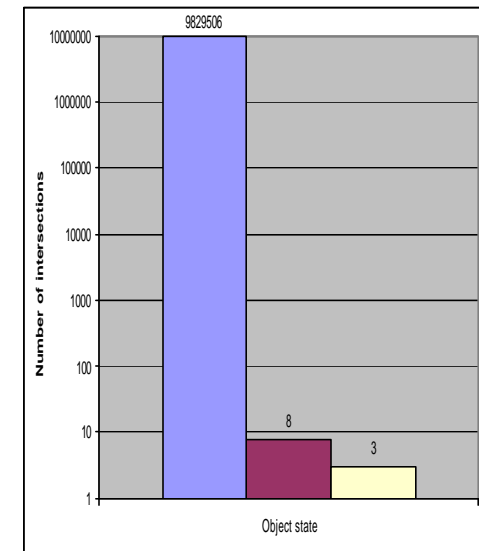
### CASE 6: Broken Rail Group Non-Harzard-free



Coverage = 0.8



Coverage = 0.9



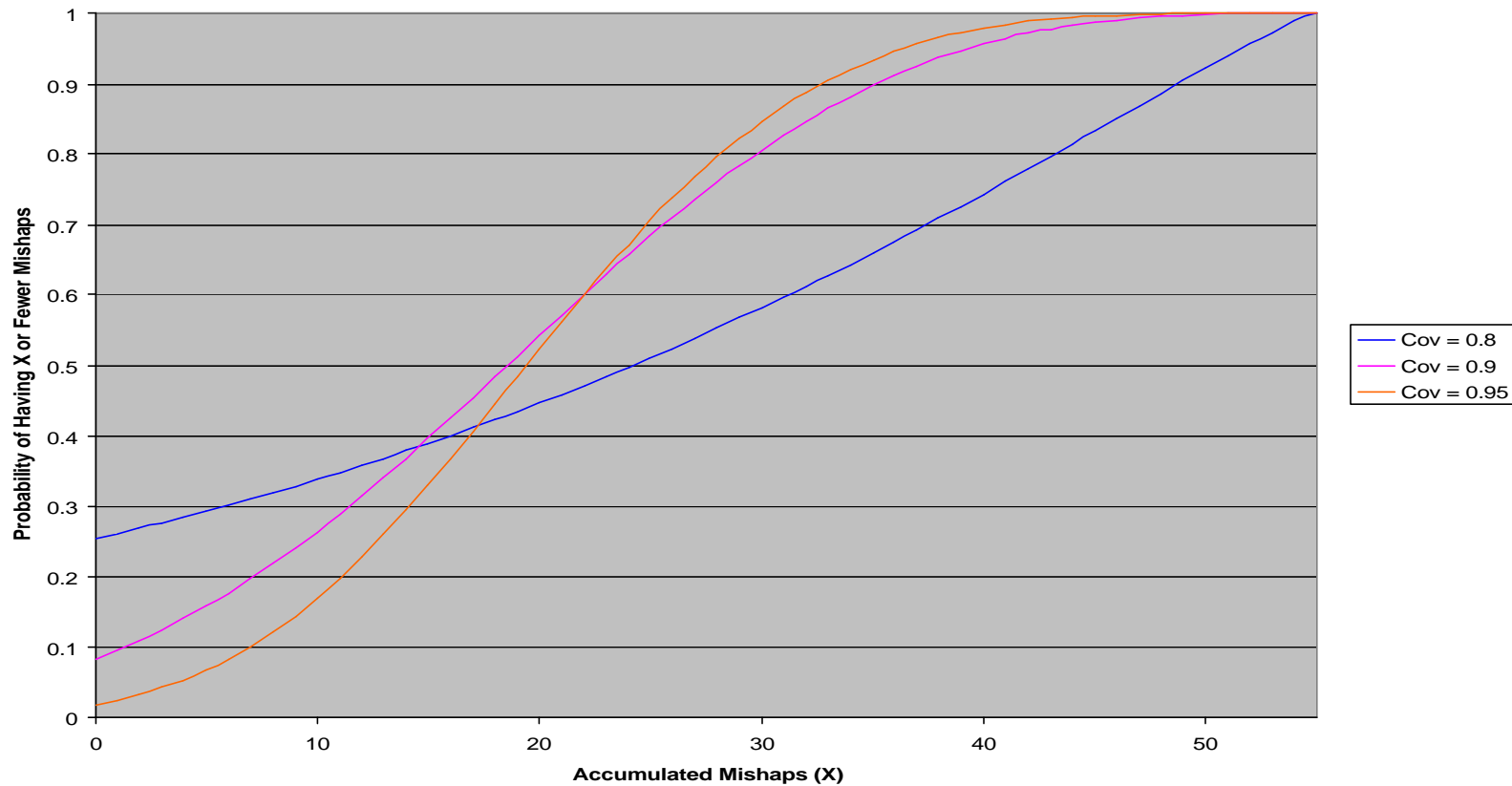
Coverage = 0.95



## Confidence: Human-factors Non-Compliance

### CASE 6: Broken Rail Group Non-Hazard-free

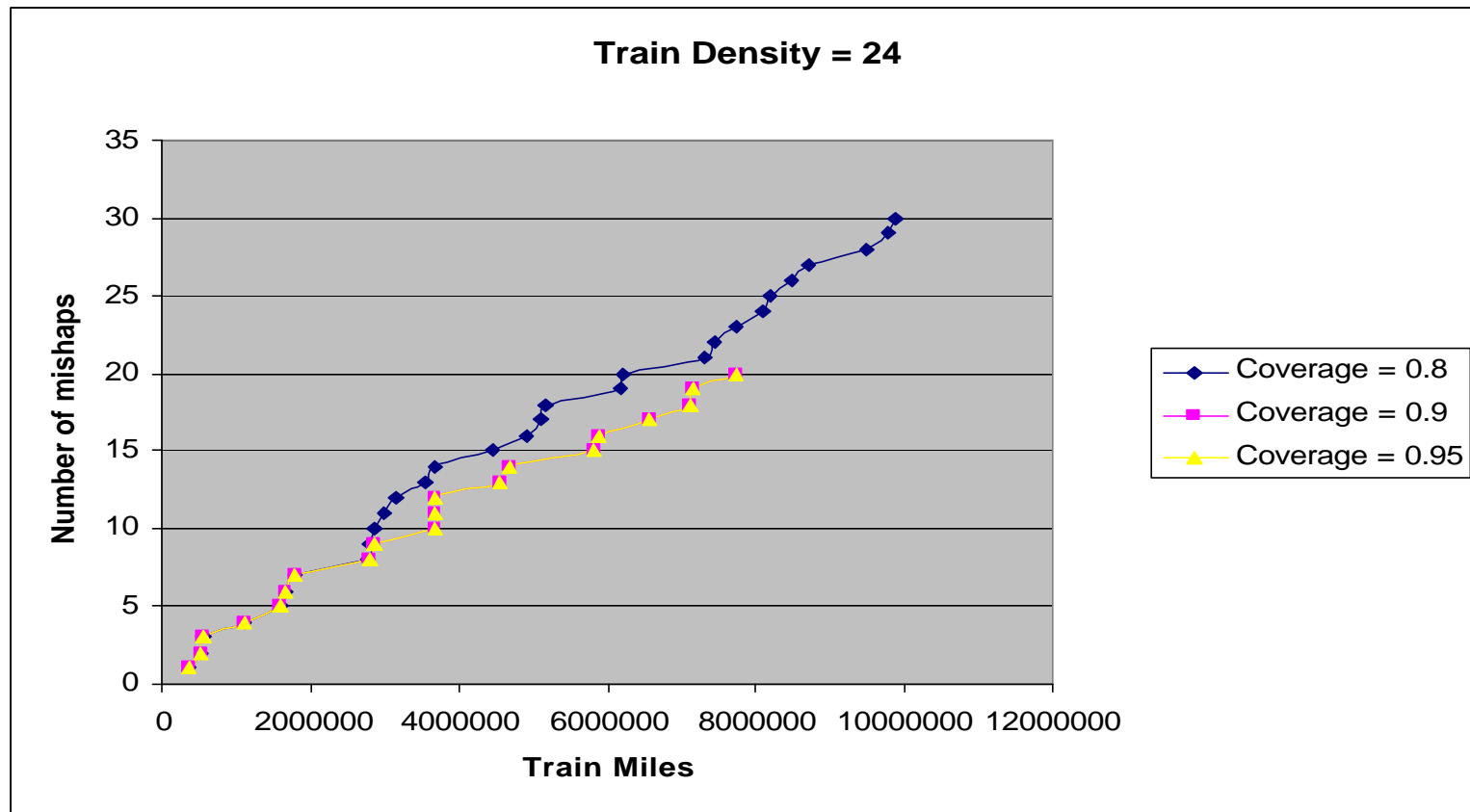
Exceedance CDF for Mishaps per Ten Million Train Miles (due to Broken Rail)





## RISK: Human-factors Non-Compliance

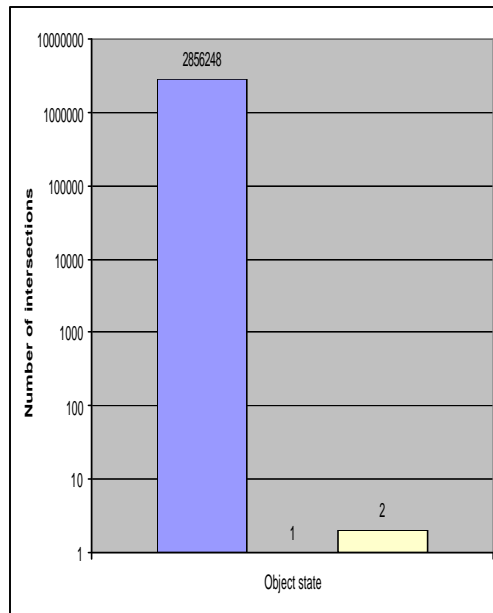
### CASE 7: Bridge Group Non-Harazard-free



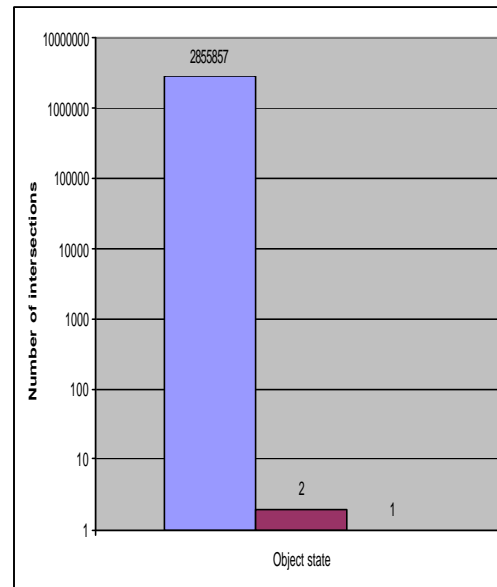


## Histogram: Human-factors Non-Compliance

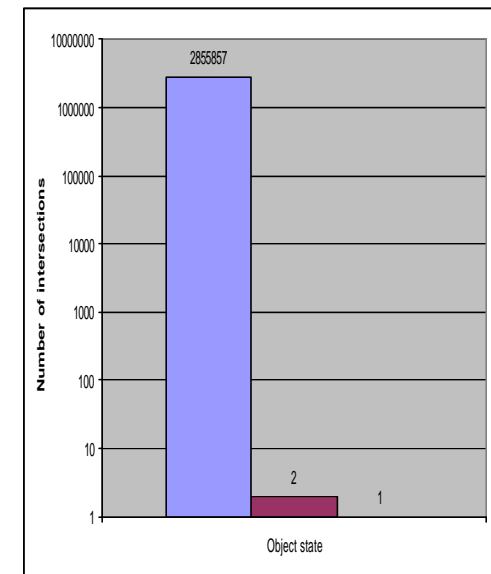
### CASE 7: Bridge Group Non-Hazard-free



Coverage = 0.8



Coverage = 0.9



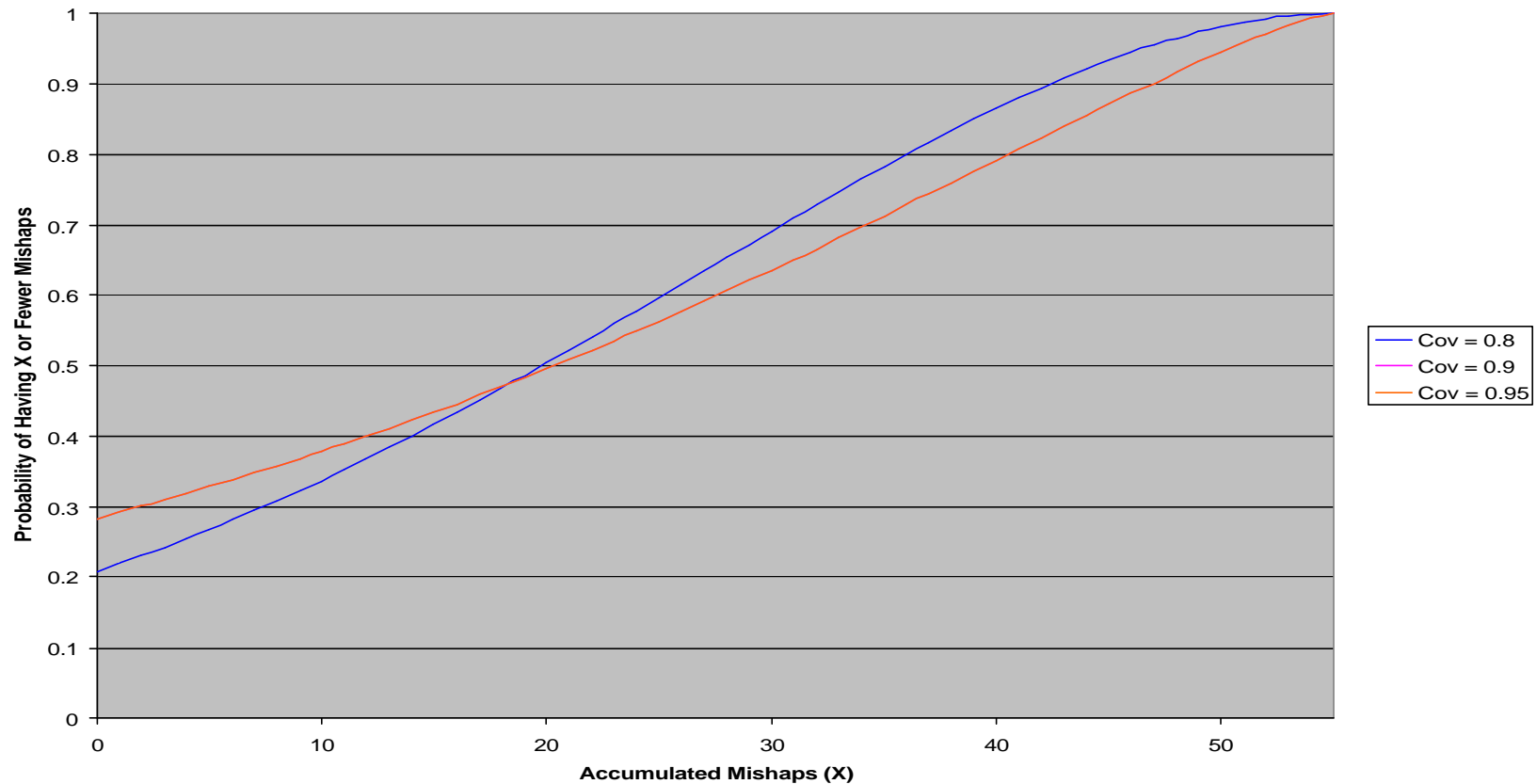
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## Confidence: Human-factors Non-Compliance

### CASE 7: Bridge Group Non-Harazard-free

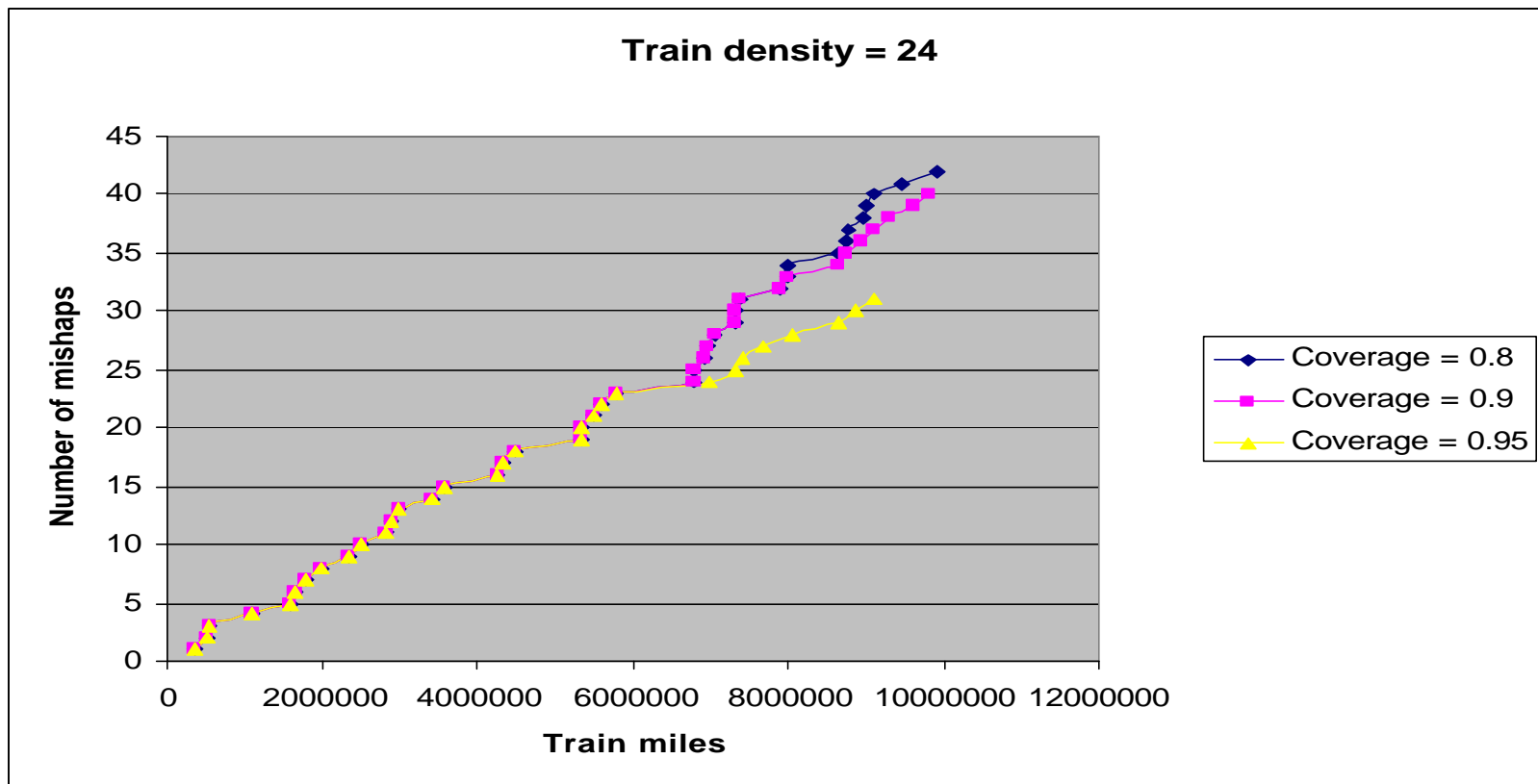
Exceedance CDF for Mishaps per Ten Million Train Miles (due to Bridges)





## RISK: Human-factors Non-Compliance

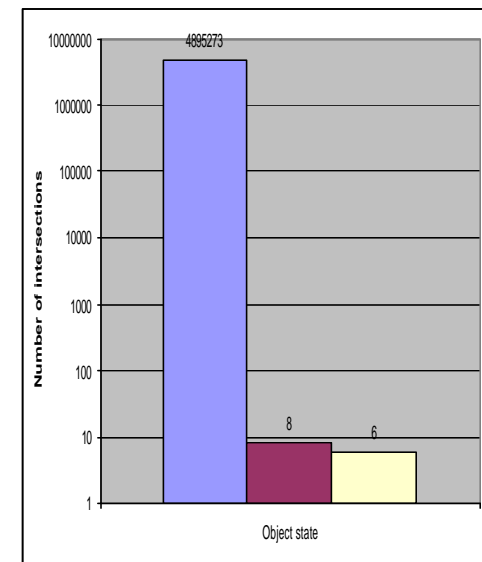
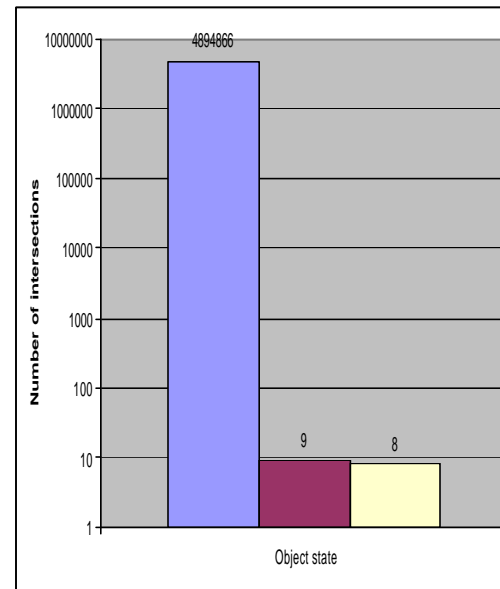
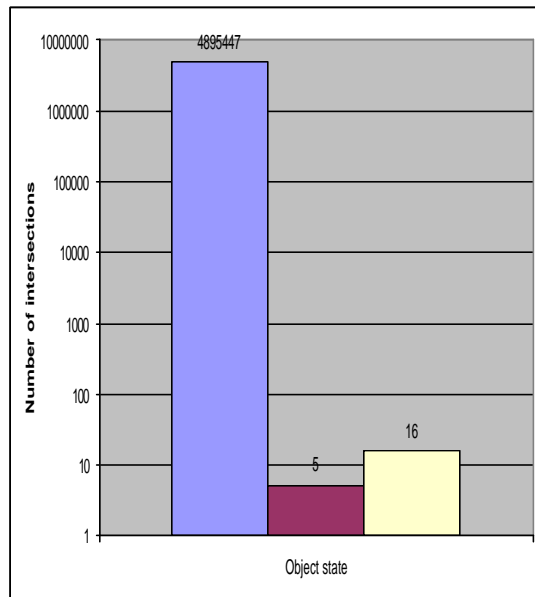
### CASE 8: Switch Group Non-Harzard-free





## Histogram: Human-factors Non-Compliance

### CASE 8: Switch Group Non-Harzard-free



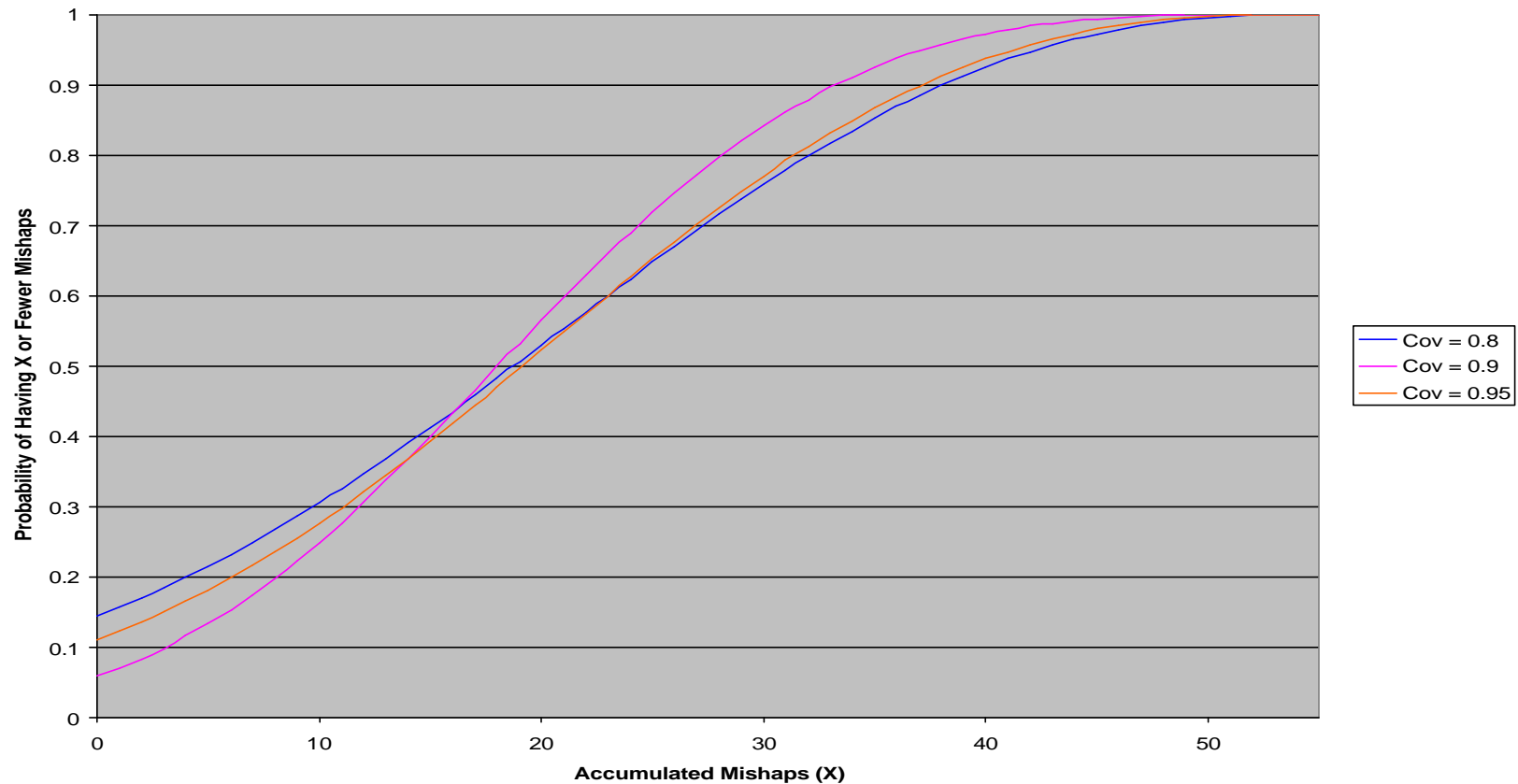


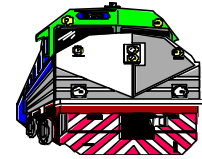


## Confidence: Human-factors Non-Compliance

### CASE 8: Switch Group Non-Hazard-free

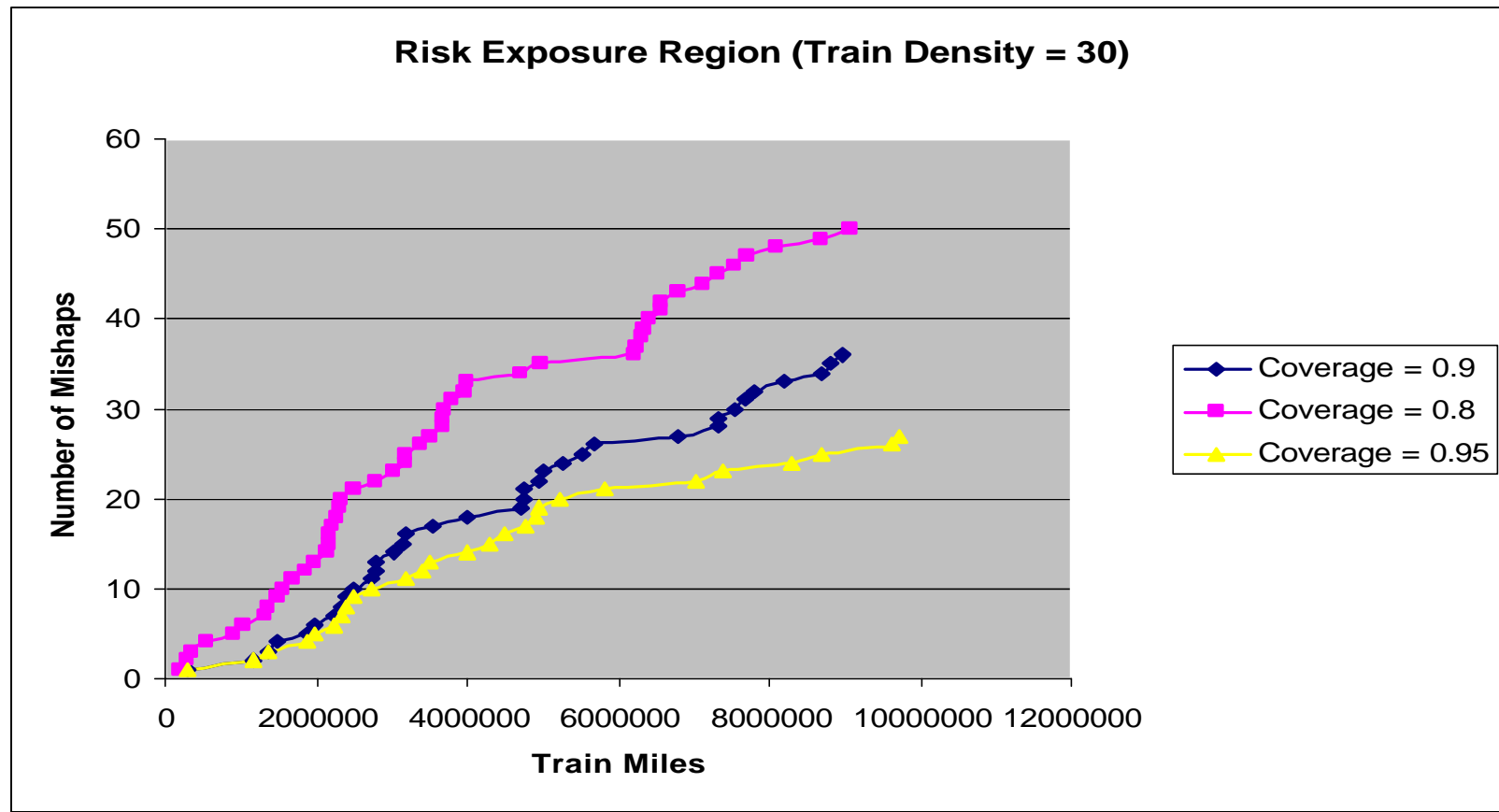
Exceedance CDF for Mishaps per Ten Million Train Miles (due to Switches)

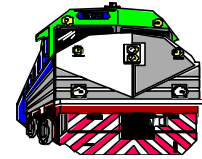




## RISK: Human-factors Non-Compliance

### CASE 10: All Object Groups Non-Hazard-Free





## Confidence: Human-factors Non-Compliance

### CASE 10: All Object Groups Non-Hazard-Free

Exceedance CDF for Mishaps per Ten Million Train Miles (entire DTC System)

